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(19) (CA) **CANADIAN PATENT** (12)

(54) Extrusion Moulding Machine for Settable Materials

(72) Kiss, Joseph L.,
Canada

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ABSTRACT OF THE DISCLOSURE

The invention provides an improved extrusion moulding machine of the type used to produce greatly elongated hollow-core, tension-reinforced slabs of hydraulic concrete or other settable material. Typically such a machine extrudes a "zero-slump" concrete mix from a mould formed between the machine and a mould floor over which it is moved by reaction of the extruded material against the already-extruded moulded portion of the slab. Screw thread conveyors are used to move the concrete mix from a hopper on the machine into the mould, and in the apparatus of the invention are provided with replaceable trailing land segments to permit replacement when worn, eliminating the need for expensive complete replacement of the conveyor screws and consequent lengthy down-time. Vibrators are provided within the mould cores that produce the hollow cores and above the mould to permit the stiff concrete mix to flow smoothly over the mould surfaces, and the vibrators' motors are provided with individual direction reversing capability, since it is found that individual adjustment of direction can give optimum operation. A preferred core cross-section is provided consisting of a "flat-topped" octagon.

EXTRUSION MOULDING MACHINE FOR SETTABLE MATERIALS

Field of the Invention

The present invention is concerned with improvements in or relating to extrusion moulding machines of the type operating with settable materials, such as hydraulic concretes.

Review of the Prior Art

Extrusion machines of the type specified have now become well-established in their industry, namely the production of articles such as slabs, panels, beams and the like from mouldable, settable materials, usually a hydraulic sand-based concrete. One form of such machine that is described for example in Canadian Patent No. 910,030, issued 19th September 1972 to George Putti, and for the manufacture of hollow-cored slabs, employs a fixed flat elongated moulding floor over which the machine moves by reaction as it extrudes the cementitious material into a movable mould, the top and side walls of which are provided by the machine, and the bottom wall of which is formed by the adjacent part of the stationary moulding floor. The cementitious mix used is as dry as possible and of "zero-slump" type that is adequately self-supporting upon its emergence from the moving mould, with the result that a machine of overall length about five metres is able to produce a continuous slab whose length is only limited by the available length of the moulding floor.

Tensioning cables are embedded in the slab as it is formed and at the same time hollow cores are formed therein extending longitudinally of the slab by means of respective

internal mould cores over which the cement is extruded by conveyors within the machine. To date the most practical form for the conveyors is a plurality of parallel externally screw-threaded members, each of which rotates about a respective parallel longitudinal axis, the conveyors being uniformly spaced across the width of the slab. Each conveyor terminates in a respective mould core which is vibrated by an internal vibrator to ensure the sufficiently free passage of the concrete over the mould core without the formation of voids. It has been found in practice that maintenance of these screw conveyors and the internal vibrators is the chief cause of down-time with the machine and resultant loss of production. Moreover, it is found with members used hitherto that repairs to these components necessitate considerable disassembly of the machine with consequent added expense and loss of production.

Definition of the Invention

It is therefore a principal object of the invention to provide a new screw conveyor structure for extrusion moulding machines of the type specified.

It is another principal object to provide a new mould core internal vibrator structure for such machines.

In accordance with the present invention there is provided an extrusion moulding machine operative with settable material and movable over a cooperating stationary mould floor by reaction of the extruding moulded material against an already-moulded portion of the article being moulded, the machine comprising:

a hopper for the reception within its interior of the settable material to be moulded;

a mould for the settable material employing as its floor the adjacent part of the said stationary mould floor and having its interior connected to the hopper interior for the receipt of settable material therefrom;

at least one screw conveyor mounted in the mould interior and rotatable to feed the settable material under pressure from the hopper interior to the mould interior, and motor means mounted by the machine and operatively connected to each screw conveyor for rotation thereof;

a mould core member mounted in the mould interior to form a continuous hollow core in the article as the settable material is conveyed over the mould core member and extruded from the mould exit;

a respective vibrator mounted within each mould core member, and motor means mounted by the machine and operatively connected to each vibrator for operation thereof, wherein

each screw conveyor comprises an externally screw-threaded member having at the leading end thereof a plurality of integral leading screw thread lands, and having at the trailing end thereof an axial support portion for a plurality of removable trailing screw thread land segments, and a plurality of trailing screw thread land segments removably fastened to said support portion and forming the conveyor trailing screw thread lands.

Preferably the axial extent of the screw thread land segments is from about 25% to about 50% of the length of the respective conveyor screw.

Also in accordance with the invention there is provided an extrusion moulding machine operative with settable material and movable over a cooperating stationary mould floor by reaction of the extruding moulded material against an already-moulded portion of the article being moulded, the machine comprising:

a hopper for the reception within its interior of the settable material to be moulded;

a mould for the settable material employing as its floor the adjacent part of the said stationary mould floor and having its interior connected to the hopper interior for the receipt of settable material therefrom;

at least one screw conveyor mounted in the mould interior and rotatable to feed the settable material under pressure from the hopper interior to the mould interior, and motor means mounted by the machine and operatively connected to each screw conveyor for rotation thereof;

a mould core member mounted in the mould interior to form a continuous hollow core in the article as the settable material is conveyed over the mould core member and extruded from the mould exit;

a respective vibrator mounted within each mould core member, and motor means mounted by the machine and operatively connected to each vibrator for operation thereof, wherein

each vibrator comprises an eccentric weight mounted between spaced bearings within the mould core member, an elongated drive shaft extending through the respective screw

conveyor and connected at one end to the said eccentric weight to rotate the weight, and said motor means for the vibrator comprises an electric motor having its drive shaft connected to the other end of the said elongated shaft. Preferably the said electric motor is reversible and electric circuit means are provided to permit reversal of the motor at will.

Further in accordance with the invention there is provided an extrusion moulding machine operative with settable material and movable over a cooperating stationary mould floor by reaction of the extruding moulded material against an already-moulded portion of the article being moulded, the machine comprising:

a hopper for the reception within its interior of the settable material to be moulded;

a mould for the settable material employing as its floor the adjacent part of the said stationary mould floor and having its interior connected to the hopper interior for the receipt of settable material therefrom;

at least one screw conveyor mounted in the mould interior and rotatable to feed the settable material under pressure from the hopper interior to the mould interior, and motor means mounted by the machine and operatively connected to each screw conveyor for rotation thereof;

a mould core member mounted in the mould interior to form a continuous hollow core in the article as the settable material is conveyed over the mould core member and extruded from the mould exit and a respective vibrator mounted within

each mould core member, and motor means mounted by the machine and operatively connected to each vibrator for operation thereof, wherein each core mould member is of flat-topped octagon transverse cross-section.

Description of the Drawings

An extrusion moulding machine that is a particular preferred embodiment of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings wherein:-

FIGURE 1 is a general perspective view of the machine from one side, internal parts being shown in broken lines, as required for adequate illustration thereof;

FIGURES 2a and 2b are together a longitudinal cross-section through the machine, taken on the line 2-2 of Figure 1, which line passes through one of the screw conveyors thereof to show its construction and illustrate its operation;

FIGURE 3 is a perspective view to an enlarged scale of an eccentric weight which is part of each conveyor mould core vibrator;

FIGURE 4 is an end elevation of the machine taken in the direction of the arrow 4 in Figure 2a, but with part of the hopper shown broken away to reveal the conveyor drive motors and with the intervening mechanism omitted;

FIGURE 5 is an exploded perspective view of the screw portion of one of the screw conveyors; and

FIGURE 6 is a diagram of part only of the electric circuit for the motors of the machine.

Description of the Preferred Embodiments

The machine of the invention forms a hollow-cored slab 10, as illustrated in Figure 1, containing six similar, uniform, continuous core passages 12 uniformly spaced across the width of the slab, the slab being formed on a smooth, elongated mould floor 14 over which the extrusion moulding machine 16 travels by reaction against the moulded portion of the slab 10, as it is moulded. Before the start of a moulding operation steel tensioning cables 18 are stretched under tension above the mould floor, so that the extruded material is moulded around them and they are embedded under tension in the resultant slab.

The machine consists of two parallel side members 20 each mounting a plurality of flanged wheels 22 that run on spaced parallel guide rails 24 embedded in the building floor on either side of the mould floor. The side members 20 are connected together along their length by various transverse members, which do not require detailed description, in order to form a rigid support frame. A hopper 26 is mounted at about the middle of the machine and its interior is fed as required with a suitable precisely-formulated hydraulic, sand-based concrete mix of the "zero-slump" type which is sufficiently dry that the moulded slab will be adequately self-supporting as it emerges from the machine mould. The mould is formed between the lower surface of a vibrating upper plate 28, two side plates 30 carried respectively by the side members 20, and the immediately adjacent portion of the mould floor 14, the interior of the mould being connected to the interior of the hopper.

Means for vibrating the upper plate 28 consist of two electric motors 32 carrying respective eccentric vibrator weights in known manner and fastened to the upper surface of the plate, which is secured via resilient connectors 34 to two supporting side structures 36 fixed securely to the side members 20. Other vibrating arrangements known to those skilled in the art can be employed instead. The mould is completed by a gravity-operated smoothing plate 38 at its exit pivoted at 40 about a transverse axis, the plate resting on the upper face of the extruded slab 10 to smooth the emerging surface; further smoothing is usually employed for a final commercially desirable finish. Two inwardly-protruding mould members 42 fixed to the inside walls of the mould side plates 30 provide respective key-slots 44 in the side edges of the moulded slab.

It is essential in commercial practice for the machine to produce a slab of uniform physical characteristics that can be pre-engineered into a structure with assurance that there will be no cracks or other problems because of the presence of voids or portions of low density. Therefore it is important for it to form the core passages 12 uniformly and continuously, and also to ensure that the tensioning cables 18 are firmly embedded in the concrete so that they will not separate in use and lose tension. To this end suitable design of the screw conveyors that feed the concrete in the mould, and of the internal moulds that form the hollow-cores are of prime importance. It will also be apparent that the installation of a machine requiring, in addition to the machine itself, the construction of a long

accurate mould floor (typically 100 metres) and guide rails, the provision of an accurately-controlled, high-quality batch mixing concrete plant, and the provision of accompanying enclosing buildings and materials handling equipment, involves large capital expenditures which must be recouped by operation of the plant as intensively as possible with minimum production of unacceptable product and with as little down-time as possible for maintenance and repairs. The achievement of these desirable conditions is made more difficult by the need to work with relatively dry "zero-slump" concrete mixes that inherently are difficult to mould and can be highly abrasive, particularly if not made to flow smoothly. The present invention provides a screw conveyor and vibrator construction that is believed to meet these desirable objectives to a much greater extent than the machines known hitherto.

As previously described this particular embodiment produces six core passages 12 in the slab 10 and accordingly the machine is provided with six of these conveyor/vibrator structures, all similar to one another. Each conveyor/vibrator structure is supported in the machine by two longitudinally spaced relatively massive cross-members 46 and 48 (Figure 2b only) on which is rotatably mounted by ball bearings 50 and 52 and thrust bearing 54 (in cross member 46) a respective drive quill 56. The six quills are rotated by two main drive motors 58 (Figure 4), each of which drives a respective lay shaft 60 via chain wheels 62 and 64 and drive chain 66. Each lay shaft drives the three adjacent quills via chain wheels 68 and 70 and

drive chain 72, the separate drives being given the respective subscripts a, b and c. Each screw conveyor member is supported by its respective quill 56 in the mould interior as a cantilever, and consists of a screw body member 74 having a forward flange 76 by which it is fastened to the quill and having a plurality of integral screw thread lands 78 at its leading end. The trailing portion of the body member 74 has a smooth cylindrical outer face 79 and the screw thread lands 80 at this trailing end of the conveyor are provided by two removable semi-cylindrical screw thread segments 82a and 82b fastened tightly to the body 74 and to one another around this cylindrical face by means of bolts 83 (Fig. 26). The segments 82a and 82b are machined and fastened to the body member 74 to ensure that the integral leading lands 78 merge smoothly and without a break with the replaceable lands 80. The leading end of the conveyor is surrounded at its bottom and sides by a semi-circular trough member 84 that cooperates with the screw conveyor to feed the concrete from the hopper interior through the mould interior.

It is found unexpectedly that the wear of the conveyor screw lands is relatively very high at their trailing ends, even with a screw design that produces a relatively smooth flow. It is believed at present that this may be due to the unavoidable pressure drop and change of flow rate as the stiff concrete mix leaves the screw lands, which apparently is accompanied by a considerable increase in the abrasiveness of the mix. Hitherto when the wear has become so substantial that it affects the performance of the screw conveyor this has necessitated the

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complete replacement of the conveyor screw, nessitating substantial disassembly of the machine. Removal of the worn screw thread segments is relatively simple and does not necessitate pulling the screw from its bearings and subsequent relatively difficult replacement and alignment. It is found in practice desirable to replace at least about 25% of the length of the screw at its trailing end, but not necessary to replace more than about 50% of the length.

Each rotatable screw conveyor has cooperating therewith a stationary core mould member and vibrator comprising an elongated stationary hollow support tube 86 (Figure 2b) that extends through corresponding aligned axial bores in the quill 56 and the screw body member 74, respective ball bearings 88 and 90 being interposed to provide a dynamic mutual support between them. The right-hand end of the tube (as seen in Figure 2b) is keyed against rotation to a transverse support member 92 of the machine frame, which also supports the respective tube end. A hollow vibrator housing 94 is fixed to the end of the tube 86, and it will be noted particularly that the exterior of the housing 94 immediately abutting the removable conveyor lands 80 is substantially a smooth continuation of the screw root, so that there will be no sudden change in pressure at this point in the flow path of the concrete as it is moved by the conveyor forward over the mould member. A hollow mould extension tube 96 (Figure 2a) is fastened to the trailing end of the housing 94 by a vibration isolating damper member consisting of a thick circular disc 98 of resilient material, such as neoprene rubber,

sandwiched between two metal plates 100 that are in turn attached respectively to the housing 94 and extension tube 96.

The vibrator for each mould consists of an eccentric weight 102 mounted at each end in respective spaced bearings 104 and 106 that are in turn securely mounted in the housing 94. The two bearings are arranged to be equally spaced from the centre of gravity of the eccentric weight on opposite sides thereof so as to equalize as much as possible the forces to which they are subjected. The weight is connected to the drive shaft of a respective reversible electric motor 108 for rotation thereby by means of an unitary elongated shaft 110 passing through the central bore in the hollow tube 86 and having its ends connected by suitable couplings to the weight and the drive shaft respectively. The speed of rotation of the weight and shaft is relatively high (i.e. 10,000 - 12,000 r.p.m.) with resultant high stresses on the vibratory system and the shaft 110 is rotatably supported against whipping at about its centre point by a ball bearing 112 interposed between it and the interior wall of the tube 86.

Each hollow mould extension tube 96 has a special transverse cross-section most clearly seen in Figure 4 which may be characterised as a flat-topped octagon. Thus, the section has eight flat sides 114a through 114h meeting at respective angles. The angles between the five lower sides 114a through 114e are substantially equal, and the sides 114a through 114f and 114h are of about the same length. However, the angles between connected sides 114a and 114h, and between connected sides 114e and 114f are much smaller and side 114g is much

shorter than the other sides to produce the required "flat-top". The resulting core passage has the advantage over the uniformly-circular cross-sections used in practice hitherto that it reduces appreciably the amount of concrete in the upper part of the slab where its contribution to strength and rigidity is at a minimum, while maintaining the required amount at the lower part of the slab surrounding the cables, where its contribution is at a maximum. A guide plate 116 is provided at the rear end of the machine to hold the tensioned cables 18 properly located between the adjacent core mould tubes.

Figure 6 illustrates schematically a suitable electrical circuit for the motors of the machine, showing only the wiring for a single drive motor 58 and a single vibrator motor 32 or 108 to avoid unnecessary repetition, standard elements such as fuses, protective relays and indicating lights and meters also being omitted. Thus, power is supplied from a suitable three phase source via a main breaker 118 to a power bus 120a, 120b, 120c; single phase power for the motor relays is taken between two of the bus elements 120b and 120c. The two drive motors 58 are supplied directly from the bus, their operation being controlled by relays 58M, which are in turn controlled by start switch 122 and stop switch 124. Power is also supplied from the bus to the field and armature of a motor 126 of a motor generator set, the generator 128 of which supplies high frequency current (360 Hz) to the vibrator motors to enable standard motors to be used for this purpose and generate the high frequency vibrations required (e.g. 10,800 Hz), without the need for a mechanical step-up gear.

The motor generator set is operated using a start switch 130 and stop switch 132. The two mould plate vibrator motors 32 and the six core mould vibrator motors 108 are started using their own start switch 134 and associated relay 136, but are stopped together with the drive motors 58 by the common stop switch 124. Each of the motors 32 and 108 is provided with a respective reversing switch 138 with associated forward relay 138F and reverse relay 138R, so that it can be reversed individually independently of its initial direction of rotation or of the direction of rotation of the other motors. The provision of such an individual reversability capability for each motor is found to be unexpectedly important in improving the operation of the machine, and especially in ensuring smooth flow of the concrete over the mould surfaces without the formation of voids. Thus, an optimum operation in this regard can be obtained upon individual selection of the direction of rotation of the vibrator weights. Periodic reversal of all of the vibrators is also found to contribute to increase of bearing life in the vibrators, with consequent decrease in down-time because of vibrator bearing failure.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An extrusion moulding machine operative with settable material and movable over a cooperating stationary mould floor by reaction of the extruding moulded material against an already-moulded portion of the article being moulded, the machine comprising:

a hopper for the reception within its interior of the settable material to be moulded;

a mould for the settable material employing as its floor the adjacent part of the said stationary mould floor and having its interior connected to the hopper interior for the receipt of settable material therefrom;

at least one screw conveyor mounted in the mould interior and rotatable to feed the settable material under pressure from the hopper interior to the mould interior, and motor means mounted by the machine and operatively connected to each screw conveyor for rotation thereof;

a mould core member mounted in the mould interior to form a continuous hollow core in the article as the settable material is conveyed over the mould core member and extruded from the mould exit;

a respective vibrator mounted within each mould core member, and motor means mounted by the machine and operatively connected to each vibrator for operation thereof, wherein

each screw conveyor comprises an externally screw-threaded member having at the leading end thereof a

plurality of integral leading screw thread lands, and having at the trailing end thereof an axial support portion for a plurality of removable trailing screw thread land segments, and a plurality of trailing screw thread land segments removably fastened to said support portion and forming the conveyor trailing screw thread lands.

2. A machine as claimed in claim 1, wherein the removable trailing screw thread land segments extend from about 25% to about 50% of the length of the respective screw conveyor.

3. A machine as claimed in claim 1, wherein each vibrator comprises an eccentric weight mounted between spaced bearings within the mould core member, and an elongated drive shaft extending through the respective screw conveyor and connected at one end to the said eccentric weight to rotate the weight, and said motor means for the vibrator comprises an electric motor having the motor drive shaft connected to the other end of the said elongated shaft.

4. A machine as claimed in claim 2, wherein each vibrator comprises an eccentric weight mounted between spaced bearings within the mould core member, and an elongated drive shaft extending through the respective screw conveyor and connected at one end to the said eccentric weight to rotate the weight, and said motor means for the vibrator comprises an electric motor having its drive shaft connected to the other end of the said elongated shaft.

5. A machine as claimed in claim 3, wherein each electric motor for a respective vibrator is reversible and electric circuit means are provided to permit reversal of the motor at will.

6. A machine as claimed in claim 3 or 4, wherein the said spaced bearings mounting the eccentric weight are spaced equidistantly from the centre of gravity of the weight, and the said shaft is a unitary member extending from the weight to the electric motor which drives the weight.

7. A machine as claimed in any one of claim 1 to 3, wherein each core mould member is of flat-topped octagon transverse cross-section.

8. An extrusion moulding machine operative with settable material and movable over a cooperating stationary mould floor by reaction of the extruding moulded material against an already-moulded portion of the article being moulded, the machine comprising:

a hopper for the reception within its interior of the settable material to be moulded;

a mould for the settable material employing as its floor the adjacent part of the said stationary mould floor and having its interior connected to the hopper interior for the receipt of settable material therefrom;

at least one screw conveyor mounted in the mould interior and rotatable to feed the settable material under

pressure from the hopper interior to the mould interior, and motor means mounted by the machine and operatively connected to each screw conveyor for rotation thereof;

a mould core member mounted in the mould interior to form a continuous hollow core in the article as the settable material is conveyed over the mould core member and extruded from the mould exit;

a respective vibrator mounted within each mould core member, and motor means mounted by the machine and operatively connected to each vibrator for operation thereof, wherein

each vibrator comprises an eccentric weight mounted between spaced bearings within the mould core member, an elongated drive shaft extending through the respective screw conveyor and connected at one end to the said eccentric weight to rotate the weight, and said motor means for the vibrator comprises an electric motor having its drive shaft connected to the other end of the said elongated shaft.

9. A machine as claimed in claim 8, wherein each electric motor for a respective vibrator is reversible and electric circuit means are provided to permit reversal of the motor at will.

10. A machine as claimed in claim 3 or 4, wherein the said spaced bearings mounting the eccentric weight are spaced equidistantly from the centre of gravity of the weight, and the said shaft is a unitary member extending from the weight to the electric motor which drives the weight.

11. A machine as claimed in claim 8 or 9, wherein each core mould member is of flat-topped octagon transverse cross-section.

12. An extrusion moulding machine operative with settable material and movable over a cooperating stationary mould floor by reaction of the extruding moulded material against an already-moulded portion of the article being moulded, the machine comprising:

a hopper for the reception within its interior of the settable material to be moulded;

a mould for the settable material employing as its floor the adjacent part of the said stationary mould floor and having its interior connected to the hopper interior for the receipt of settable material therefrom;

at least one screw conveyor mounted in the mould interior and rotatable to feed the settable material under pressure from the hopper interior to the mould interior, and motor means mounted by the machine and operatively connected to each screw conveyor for rotation thereof;

a mould core member mounted in the mould interior to form a continuous hollow core in the article as the settable material is conveyed over the mould core member and extruded from the mould exit and a respective vibrator mounted within each mould core member, and motor means mounted by the machine and operatively connected to each vibrator for operation thereof, wherein each core mould member is of flat-topped octagon transverse cross-section.

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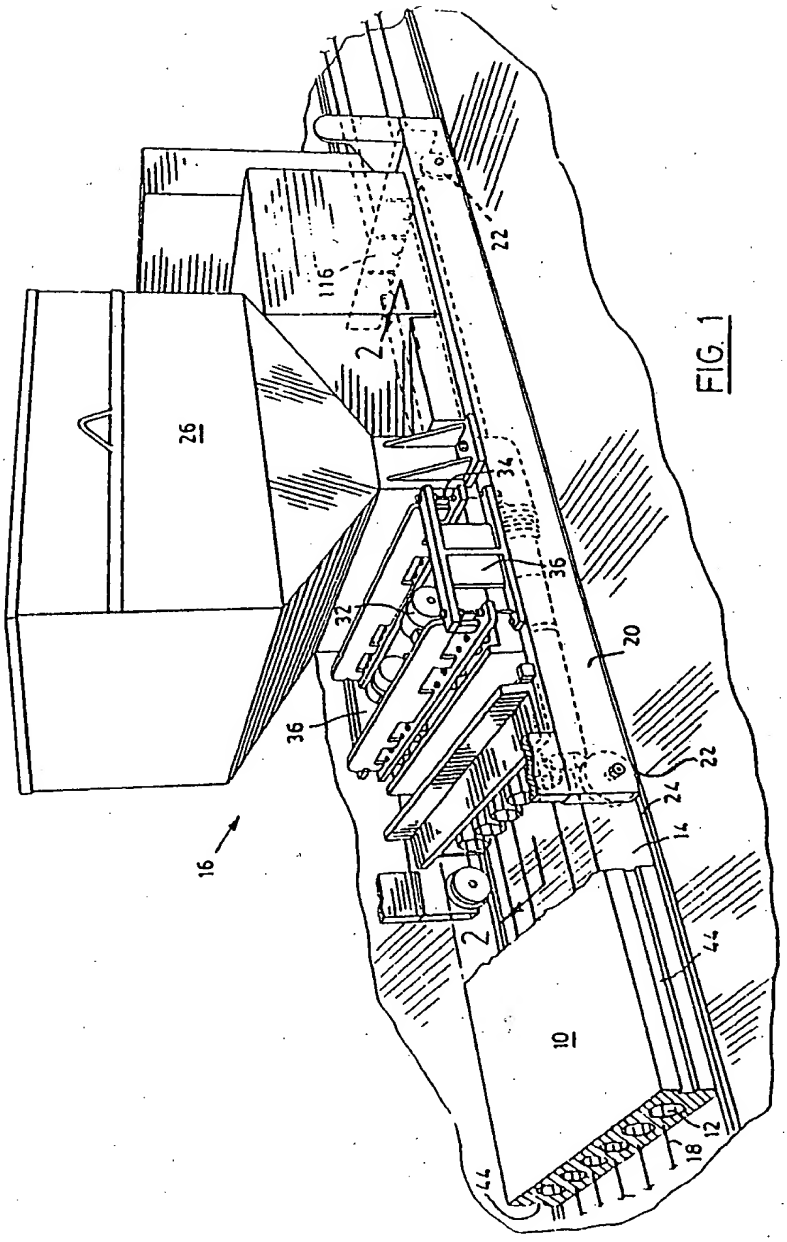

FIG. 1

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Agents for the Applicant/s

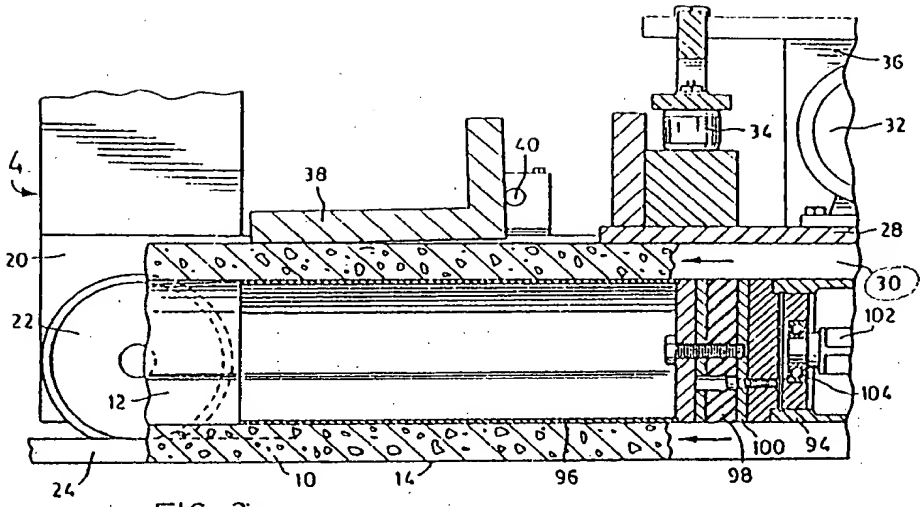

FIG. 2a

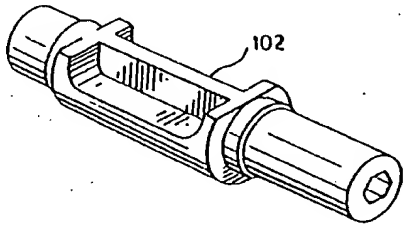

FIG. 3

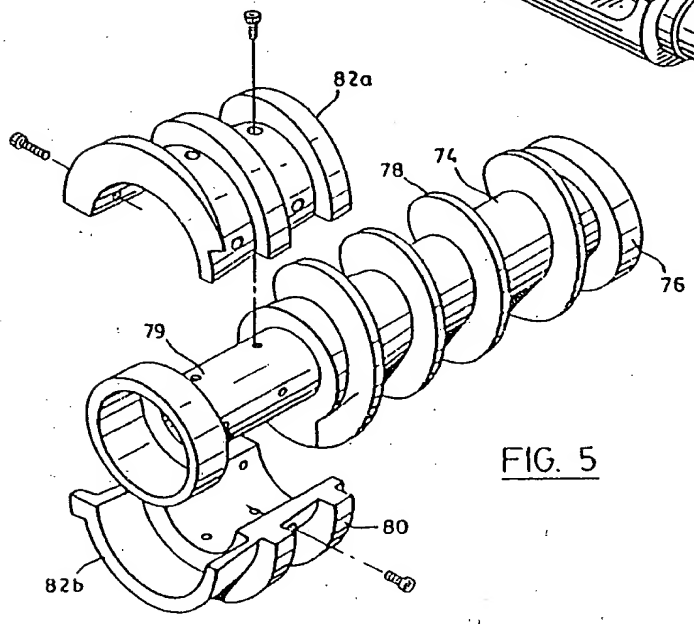

FIG. 5

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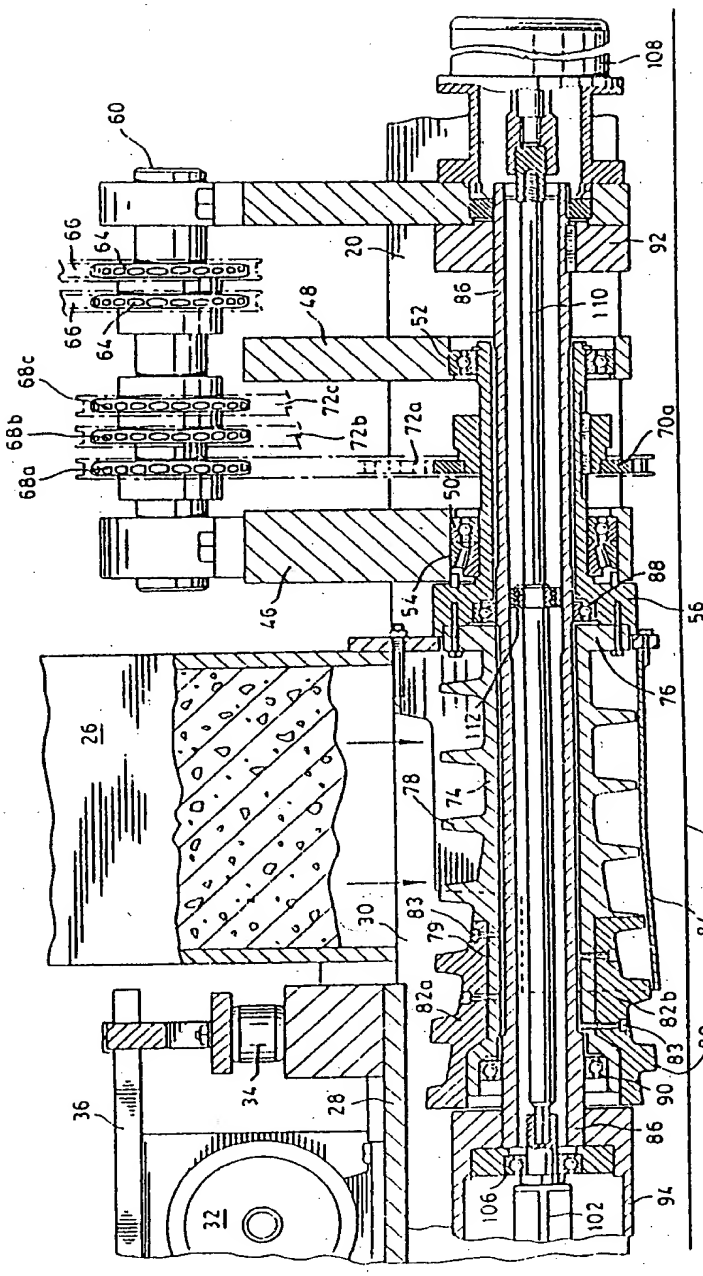

FIG. 2b

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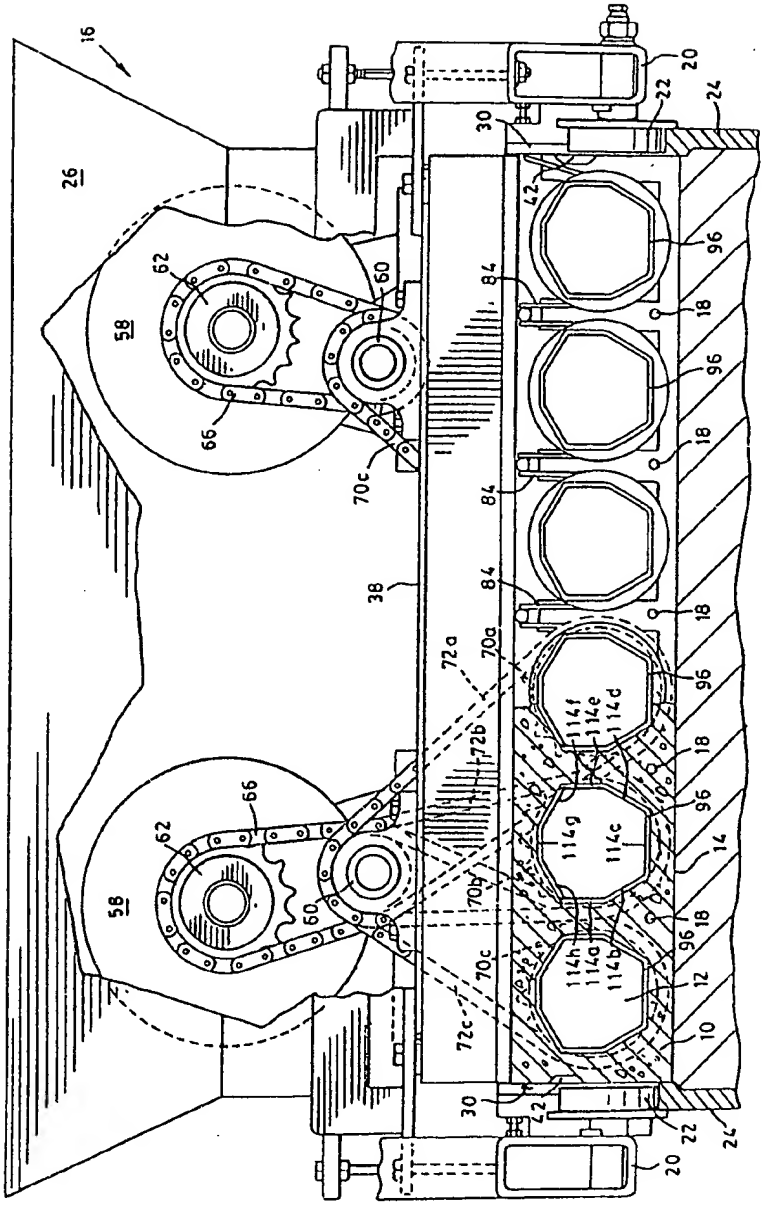

FIG. 4

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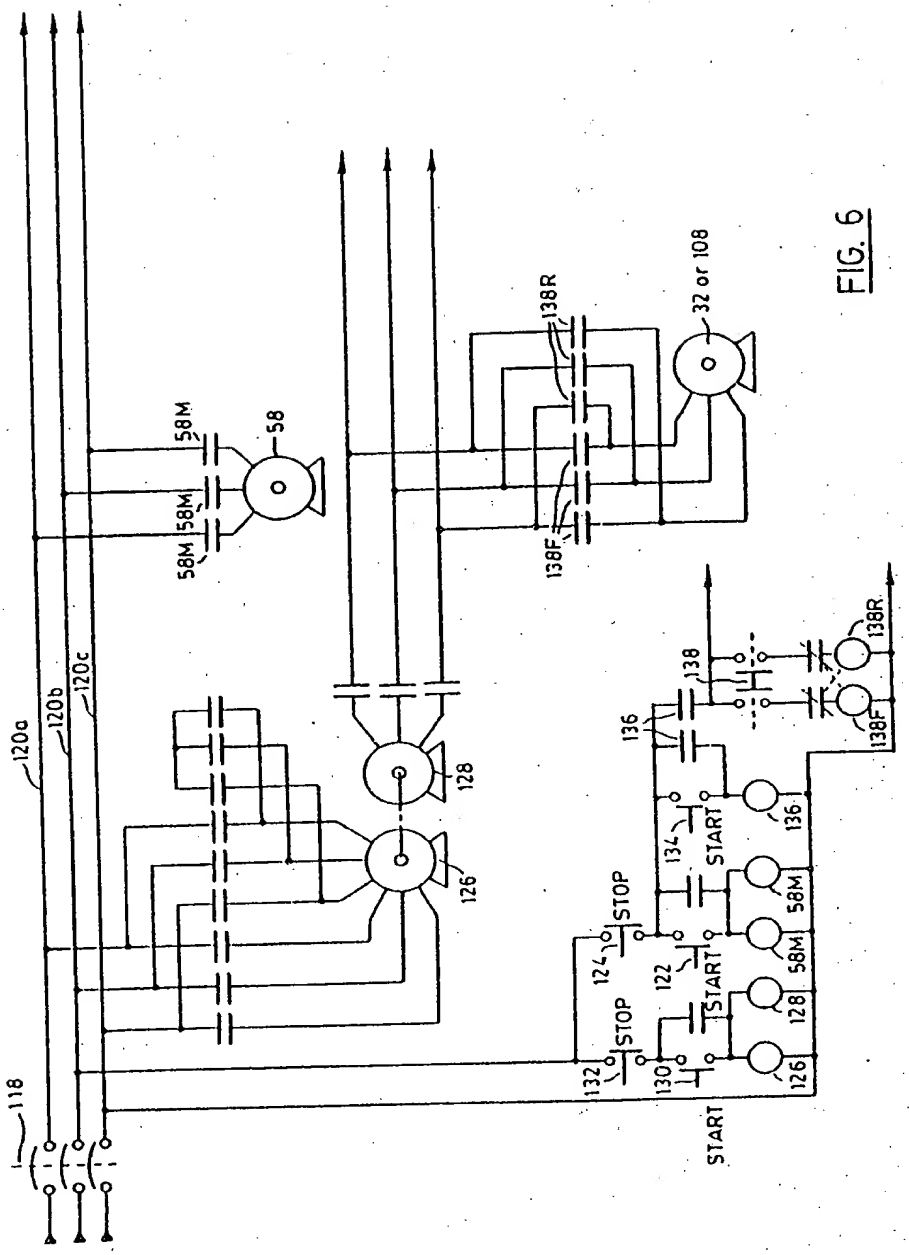

FIG. 6

Wilson, Pryor & Scott

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